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EVT 38-88

MIL-STD-1660 TESTING OF LAMINATED WOOD PALLETS

Prepared for:

U.S. Army Armament Research, Development and Engineering Center
ATTN: SMCAR-ESK
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The U.S. Army Defense Ammunition Center and School (USADACS), Evaluation Division (SMCAC-DEV), was tasked by the U.S. Army Armament, Research, Development and Engineering Center (ARDEC), SMCAR-ESK, Rock Island, IL, to obtain and test laminated wood pallets weighing 3,000 and 4,000 pounds as an alternative to hardwood pallets. The pallets that were tested were made of Red Oak, White Spruce, and Aspen two-ply laminates. Pallet sizes tested were 40 by 48 inches and 42 by 53 inches. Each of the initial 12 pallets that were tested were composed of single wood types. An additional hybrid pallet was also constructed utilizing Aspen wood for the skids and deck, and Red Oak for the posts. Results from the test indicated that pallets constructed entirely of softwood would be inadequate in satisfying MIL-STD-1660 criteria. The Red Oak pallets that were tested performed well undergoing MIL-STD-1660 without sustaining any damage. The hybrid pallet that was tested also performed well; but did; however, sustain minor damage during the test.

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REPORT NO. EVT 33-88

MIL-STD-1660 TESTING OF LAMINATED WOOD PALLETS

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PART 1

INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center and School (USADACS), Evaluation Division, was tasked by the U.S. Army Armament, Research, Development and Engineering Center (ARDEC), SMCAR-ESK, to obtain and test two-ply laminated wood pallets with loads weighing 3,000 and 4,000 pounds in sizes of 42 by 53 inches and 40 by 48 inches. Pallets were constructed utilizing specifications in MIL-P-15011J. The laminated lumber used to construct the pallets was obtained from Sentinal Structures, Inc., Peshtigo, WI. Attempts were made to obtain Red Oak, Pine, Fir, Larch, Spruce, Aspen, and Cottonwood; however, only Red Oak, Spruce, and Aspen laminated lumber could be obtained. An additional softwood laminated pallet was also tested utilizing Red Oak posts to see if a hybrid pallet would satisfy MIL-STD-1660 criteria.

B. AUTHORITY. This test was conducted in accordance with mission responsibilities delegated by the U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island, IL.

C. OBJECTIVE. The objective of these tests is to assess the capability of pallets constructed of laminated lumber to meet Army functional/operational requirements for MIL-STD-1660, Design Criteria for Ammunition Unit Loads.

PART 2

ATTENDEES

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PART 3

TEST PROCEDURES

The test procedures outlined in this section were extracted from MIL-STD-1660, Design Criteria for Ammunition Unit Loads (8 April 1977). MIL-STD-1660 identifies four steps the unitized load must undergo if it is considered to be acceptable. These tests are synopsized below:

1. STACKING TESTS. The unit load shall be loaded to simulate a stack of identical unit loads stacked 16 feet high, for a period of one hour. This stacking load is simulated by subjecting the unit load to a compression of weight equal to an equivalent 16-foot stacking height. The compression load is calculated in the following manner. The unit load weight is divided by the unit load height in inches and multiplied by 192. The resulting number is the equivalent compressive load of a 16-foot-high unit stack.

2. REPETITIVE SHOCK TEST. The repetitive shock test shall be conducted in accordance with Method 5019, Federal Standard 101. The test procedure is as follows: The test specimen shall be placed on, but not fastened to, the platform. With the specimen in one position, vibrate the platform at 1/2-inch amplitude (1-inch double amplitude) starting at a frequency of about 3 cycles per second. Steadily increase the frequency until the package leaves the platform. The resonant frequency is achieved when a 1/16-inch-thick feeler may be momentarily slid freely between every point on

the specimen in contact with the platform at some instance during the cycle or a platform acceleration achieves a magnitude of ±1 G. Midway into the testing period the specimen shall be rotated 90 degrees and the test continued for the duration. Unless failure occurs, the total time of vibration shall be two hours if the specimen is tested in one position; and, if tested in more than one position, the total time shall be three hours.

3. EDGEWISE DROP TEST. This test shall be conducted by using the procedures of Method 5008, Federal Standard 101. The procedure for the Edgewise Drop (Rotational) Test is as follows: The specimen shall be placed on its bottom with one end of the base of the container supported on a sill nominally 6 inches high. The height of the sill shall be increased, if necessary, to ensure that there will be no support for the base between the ends of the container when dropping takes place, but should not be high enough to cause the container to slide on the supports when the dropped end is raised. The unsupported end of the container shall then be raised and allowed to fall freely to the concrete, pavement, or similar underlying surface from a prescribed height. Unless otherwise specified, the height of drop for level A protection shall conform to the following tabulation:

Table 1: Drop Levels

GROSS WEIGHT NOT EXCEEDING	DIMENSIONS ON ANY EDGE NOT EXCEEDING	HEIGHT OF DROP LEVEL A PROTECTION
600 lbs.	72 inches	36 inches
3,000 lbs.	no limit	24 inches
no limit	no limit	12 inches

4. IMPACT TEST. This test shall be conducted by using the procedure of Method 5023, Incline-Impact Test of Federal Standard 101. The procedure for the Incline-Impact Test is as follows: The specimen shall be placed on the carriage with the surface or edge which is to be impacted projecting at least 2 inches beyond the front end of the carriage. The carriage shall be brought to a predetermined position on the incline and released. If it is desired to concentrate the impact on any particular position on the container, a 4- by 4-inch timber may be attached to the bumper in the desired position before the test. No part of the timber shall be struck by the carriage. The position of the container on the carriage and the sequence in which surfaces and edges are subjected to impacts may be at the option of the testing activity and will depend upon the objective of the tests. When the test is to determine satisfactory requirements for a container or pack, and, unless otherwise specified, the specimen shall be subjected to one impact on each surface that has each dimension less than 9.5 feet. Unless otherwise specified, the velocity at time of impact shall be 7 feet per second.

PART 4

TABLE 2: TEST EQUIPMENT		
Test Device	Specification	Description
COMPRESSION TESTER	Manufacturer	Ormond Manufacturing
	Platform	60 inches by 60 inches
	Compression Limit	50,000 pounds
	Tension Limit	50,000 pounds
TRANSPORTATION SIMULATOR	Manufacturer	Gaynes Laboratory
	Capacity	6,000-pound pallet
	Displacement	1/2-inch Amplitude
	Speed	50 to 400 rpm
	Platform	5 foot by 8 foot
INCLINED RAMP	Manufacturer	Conbur Incline
	Type	Impact Tester
	Grade	10 percent Incline
	Length	12-foot Incline

TABLE 3: TEST SPECIMENS					
Pallet Type	Length (Inches)	Width (Inches)	Height (Inches)	Weight (Pounds)	Test Results
White Spruce	48 - 1/4	40	34 - 1/4	2743	FAILED
	53	42 - 1/4	34	2905	FAILED
	48	40	49	4050	FAILED
	53	42 - 1/4	49 - 1/2	4050	PASSED
Aspen	48 - 1/8	40 - 1/4	34 - 1/8	2750	FAILED
	53	42 - 1/8	34 - 1/4	2900	PASSED
	48	40	48 - 3/4	4050	FAILED
	53	42 - 1/4	49 - 1/2	4080	FAILED
Red Oak	48	40	34 - 1/4	2778	PASSED
	53	42 - 1/2	35	2930	PASSED
	48	40	48 - 3/4	4050	PASSED
	53	42 - 1/4	49 - 1/2	4080	PASSED
Hybrid Pallet	53 - 1/2"	42 - 1/2	48 - 7/8	4100	PASSED

PART 5

TEST RESULTS

1. STACKING TEST. The 3,000- and 4,000-pound test pallet units were loaded with approximatly 15,500 and 16,500 pounds, respectively, for a period of one hour. None of the pallets sustained any damage from the stacking test.

2. REPETITIVE SHOCK TEST. The test pallets were subjected to the longitudinal and lateral vibration for 90 minutes in each direction. The rotational speed was adjusted for each pallet in order to achieve the required 1/16-inch clearance between the pallet and the Transportation Simulator bed. See Table 4 for rotational speeds used during the tests.

TABLE 4: TEST SPECIMENS

Pallet Type	Length (Inches)	Weight (Pounds)	Longitudinal Test Speed (RPM)	Lateral Test Speed (RPM)
White Spruce	48 - 1/4	2743	215	180
	53	2905	230	200
	48	4050	225	170
	53	4050	230	215
Aspen	48 - 1/8	2750	235	210
	53	2900	185	170
	48	4050	200	175
	53	4080	210	200
Red Oak	48	2778	200	185
	53	2930	185	175
	48	4050	200	170
	53	4080	200	185
Hybrid Pallet	53 - 1/2	4100	175	170

Results from the repetitive shock test indicated that pallets composed entirely of softwood would not meet MIL-STD-1660 criteria. Several of the softwood pallets that were tested had problems holding the skids to the posts. The nails that were used to attach the skids to the post either pulled through the softwood skid or pulled out of the softwood post. Also, the outer deck boards were damaged when the bands either pulled into the edge of the wood or warped the outer edge boards causing the nails to pull from the deck. The hardwood pallets that were tested performed well undergoing the repetitive shock test without sustaining any damage. The hybrid pallet that was tested also performed well and only sustained minor damage from the repetitive shock test. Damage to the hybrid pallet consisted of a minor crack in an upper deck board and several cracks in the skids.

3. EDGEWISE DROP TEST. Each side of the pallet base was placed on a beam displacing it 6 inches above the floor. The opposite side was raised to a height of 12 inches for the 4,000-pound pallets and 24 inches for the 3,000-pound pallets, and then dropped. This process was repeated in a clockwise direction until all four sides of the pallet had been tested.

Results from the edgewise drop test indicated that the softwood pallets could pass the edgewise drop test but not without sustaining heavy damage. Typical damage on the softwood pallets was broken skid tips. The hardwood laminated pallets passed the test with only minor damage to one pallet. The hybrid pallet also passed the edgewise drop test without sustaining any additional damage.

5. IMPACT TEST. The incline impact tester was set to allow the pallet to travel 8 feet before impacting the bumper of the impact tester. In between impacts, the pallet was rotated in a clockwise direction until all four sides of the pallet had been impacted. No additional damage was sustained by any of the pallets from the impact testing.

PART 6

CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS. The purpose of these tests was to find a suitable replacement to hardwood pallets. Since the laminated softwood pallets sustained heavy damage from the MIL-STD-1660 testing, the laminated softwood would not be a suitable replacement for the hardwood pallets. The laminated Red Oak would be a suitable replacement for non-laminated Red Oak, but would probably be just as hard to obtain as regular Red Oak and more costly. The hybrid pallet with the softwood laminated deck, softwood skids, and hardwood laminated posts would also be a suitable replacement for non-laminated Red Oak pallets; however, the pallet would not be as durable as a standard hardwood pallet.

2. RECOMMENDATIONS. Recommend that the hybrid pallet be tested again utilizing hardwood laminated skids; softwood deck, except for the outer two upper deck boards; laminated hardwood on the outer two upper deck boards; and hardwood laminated posts. The replacement of the outer two upper deck boards and skids with laminated hardwood would elimate the damage that was sustained when the banding pulled into the deck boards and would increase the lifetime of the pallet. Aiso, a similar hybrid pallet should be built utilizing non-laminated lumber. This non-laminated pallet would also have hardwood skids; softwood deck, except for the outer two upper deck boards; hardwood on the outer two upper deck boards; and hardwood posts. If acceptable, the non-laminated pallet would be much cheaper to field than a laminated pallet of similiar

construction. A final recommendation, resulting from these tests, would be to investigate the possibility of using laminated hardwood posts on all future pallets that are produced. The laminated posts have an advantage over solid hardwood posts in that the laminated posts can be constructed out of smaller pieces of hardwood without any loss in strength and durability, and would be less susceptible to splitting or cracking as wood moisture content decreases.

PART 7

PHOTOGRAPHS

90-3577 **DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL**

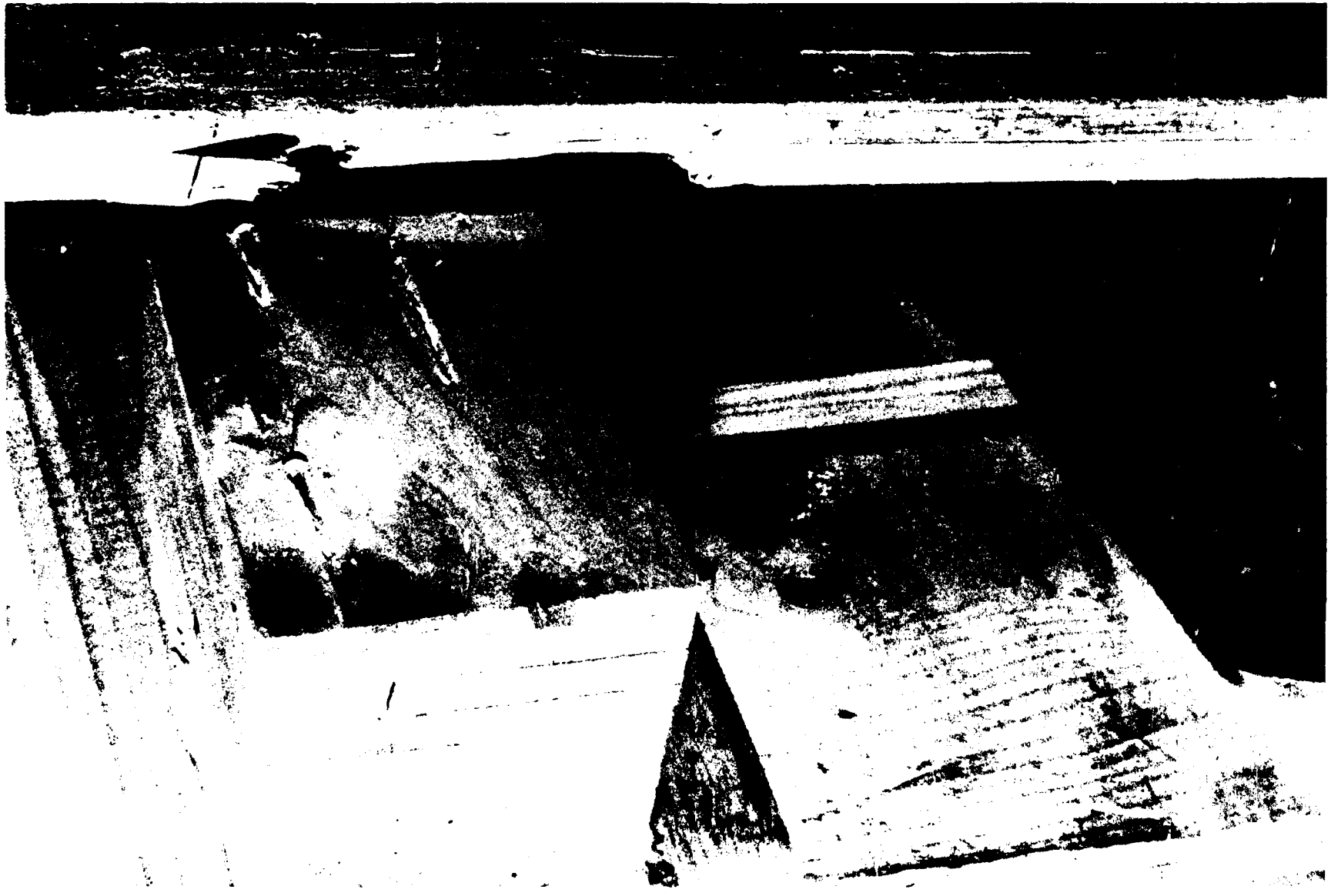
Photo 1: This photo shows a laminated Red Oak pallet after completion of MIL-STD-1660 testing.

89-6115 **DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL**

Photo 2: This photo shows the type of damage the softwood laminated pallets were sustaining from the edgewise rotational drop test.

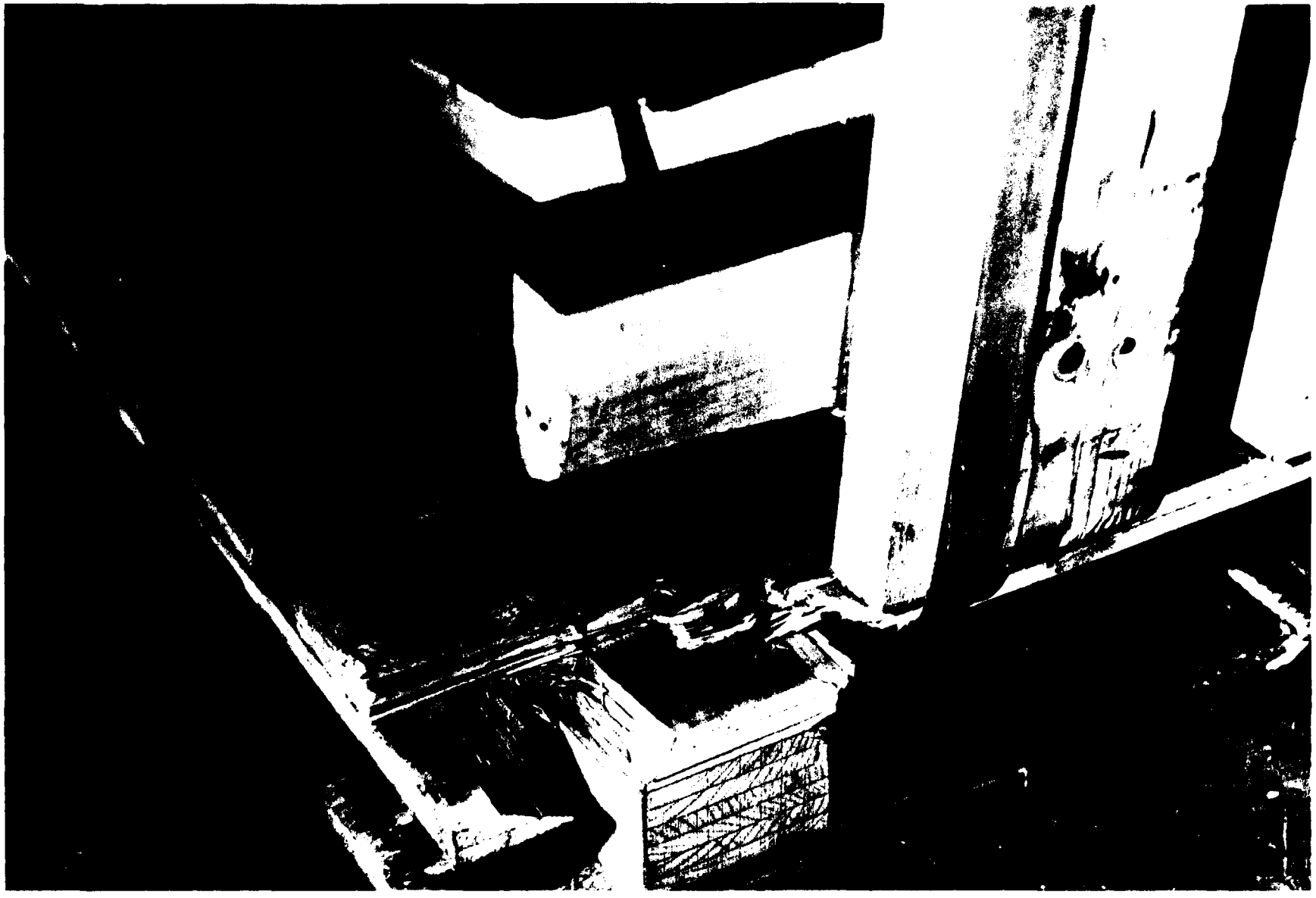
89-6123 **DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL**

Photo 3: This photo shows typical deck damage and the failure of the nails to hold the skids to the posts on the laminated wood pallets.



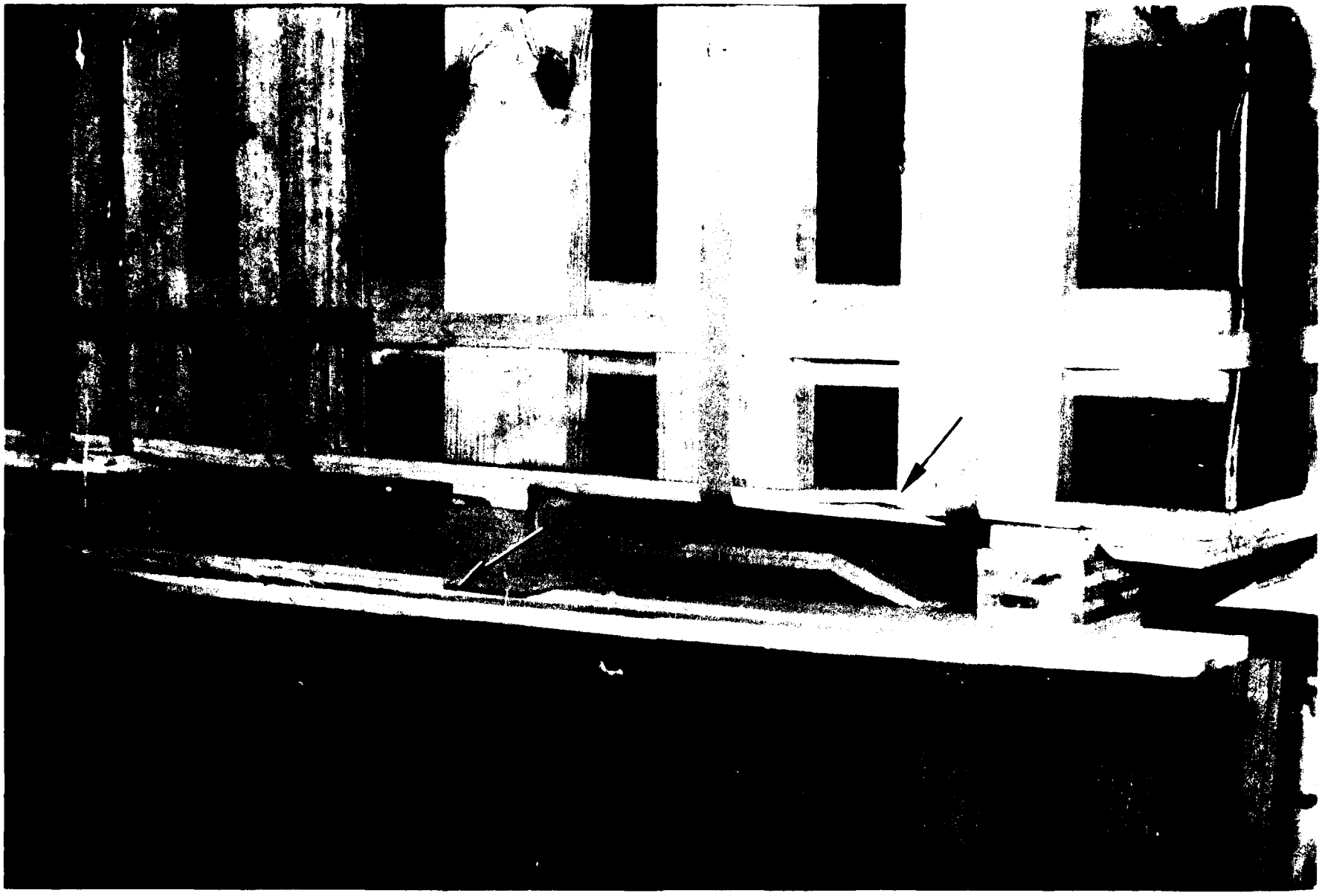
89-4165 **DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL**

Photo 4: This photo also shows the failure of the nails to hold the skids to the posts on the softwood laminated pallets.



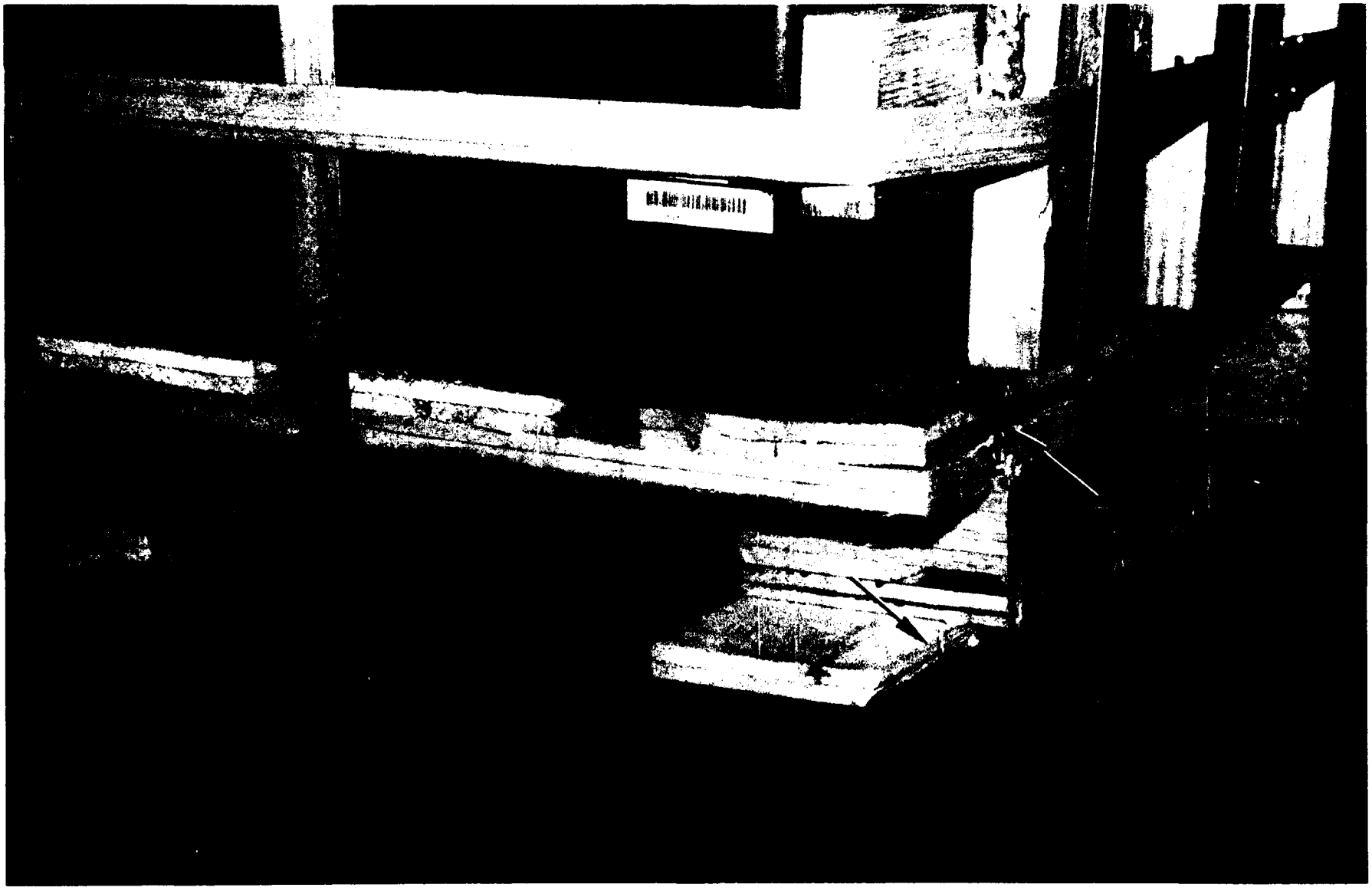
89-3206 **DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL**

Photo 5: This photo shows the damage that was sustained during a slinging operation with a basket chain sling.



89-4857 **DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL**

Photo 6: This photo shows the damage that the hybrid pallet sustained on the skids and upper deck boards.



89-4856 **DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL**

Photo 7: This photo shows additional damage that the hybrid pallet sustained on the skids and upper deck boards.